David H. Becker (OSB # 081507)
Law Office of David H. Becker, LLC
4110 SE Hawthorne Blvd. # 168
Portland, OR 97214
(503) 388-9160
davebeckerlaw@gmail.com

Talasi B. Brooks (*Pro hac vice*)
Western Watersheds Project
PO Box 2863
Boise, ID 83701
(208) 336-9077
tbrooks@westernwatersheds.org

Paul D. Ruprecht (OSB # 132762)
Western Watersheds Project
PO Box 12356
Reno, NV 89510
(208) 421-4637
paul@westernwatersheds.org

Attorneys for Plaintiffs Western Watersheds Project, Center for Biological Diversity, and WildEarth Guardians

IN THE UNITED STATES DISTRICT COURT

FOR THE DISTRICT OF OREGON

PENDLETON DIVISION

WESTERN WATERSHEDS PROJECT, CENTER FOR BIOLOGICAL DIVERSITY, and **WILDEARTH GUARDIANS,**

Plaintiffs,

v.

DAVID BERNHARDT, Secretary of the Interior, **JEFFREY A. ROSE,** District Manager, Burns District Bureau of Land Management, and **BUREAU OF LAND MANAGEMENT,**

Defendants.

Case No.: 2:19-cv-750-SI

DECLARATION OF DALE A. McCULLOUGH, Ph.D.

I, DALE A. McCULLOUGH, state and declare as follows:

1. I have a B.S. in Zoology from Ohio University, an M.S. in Biology from Idaho State University, and a Ph.D. in Fisheries from Oregon State University. Until June, 2017, I was employed as a Senior Fishery Scientist for the Columbia River Inter-Tribal Fish Commission (CRITFC) for 32 years. In that capacity, I have studied, written, and presented on salmonid habitat throughout the Columbia River basin. I led a 10-year Bonneville Power Administration-funded study of salmonid habitat restoration in NE Oregon (upper Grande Ronde River and Catherine Creek), revealing rate of restoration of key habitat limiting factors in watersheds subject to impacts of cattle grazing, timber harvest, and agriculture. In particular, I have focused much of my work on the harmful effects of temperature on Pacific Northwest salmon, steelhead (*Oncorhynchus mykiss*, incl. redband trout), and bull trout and have been a technical expert in this field in the Pacific Northwest in various capacities for 28 years. My evaluations of fish habitat quality also focused significantly on the impacts of fine sediments in spawning gravels, rate of riparian vegetation recovery (including stream shade), water temperature trends, streamflow, stream channel morphology recovery, large woody debris, pool depth and frequency, and linkages to fish populations.

2. In this report I express what I consider to be a review of the general effects of unrestricted livestock grazing on streambanks, riparian zones and instream fish habitat. I categorize these impacts as to their likely effects on salmonid habitat quantity, quality, and spatial distribution, and thereby indicate the likely impacts on redband trout abundance and productivity if riparian and instream fish habitat are damaged. The opinions in this report are based on my publication "Review and Synthesis of Effects of Alterations to the Water Temperature Regime on Freshwater Life Stages of Salmonids, with Special Reference to

Chinook Salmon," prepared for the United States Environmental Protection Agency (Feb. 22, 1999); my experience working as a technical member of the Temperature Subcommittee for the Oregon Department of Environmental Quality 1992-1994 Water Quality Standards Review (March 10, 1993); my work in collaboration with the United States Environmental Protection Agency (EPA), National Oceanic and Atmospheric Administration (NOAA), United States Fish and Wildlife Service (USFWS), and the state water quality agencies in developing temperature criteria for the Columbia River salmon, steelhead, and bull trout populations (EPA 2003, McCullough et al. 2001), numerous reviews of water quality standards (especially water temperature) developed by the states of Oregon, Washington, and Idaho; my work as a technical advisor for the Colorado Department of Public Health and Environment in revising their water temperature standards; work as a member of the NOAA Interior Columbia Fisheries Technical Recovery Team to restore Columbia River salmon and steelhead; field research as the project leader for a 10-year study of stream recovery in the upper Grande Ronde basin in NE Oregon; my knowledge of the scientific literature, and my own professional knowledge and experience gained from 47 years of work in the field of aquatic ecology and fisheries; experience I have gained in monitoring the recovery of fish habitat after impact from livestock grazing in the Grande Ronde basin, the John Day basin, and the Warm Springs River of Oregon; my publications on monitoring fish habitat such as "McCullough, D.A. and M.J. Greene. 2005. *Monitoring fine sediment: Grande Ronde and John Day Rivers.* Final report to Bonneville Power Administration. Project No. 1997-034-00. CRITFC Technical Report 5-1.", "McCullough, D.A. 1999. *Monitoring of streambank stability and streamside vegetation in a livestock exclosure on the Warm Springs River, Oregon: Comparison of ground-based surveys with aerial photographic analysis.* Prepared for the Confederated Tribes of the Warm Springs Reservation

of Oregon under a special services contract to the Bonneville Power Administration, Project number (BPA) 96FC96721. 182 p.," McCullough, D.A. and F.A. Espinosa, Jr. 1996. *A monitoring strategy for application to salmon-bearing watersheds.* Tech. Report 96-5. Columbia River Inter-Tribal Fish Commission, Portland, Oregon. 170 p. + appendices.,", and "Rhodes, J.J., D.A. McCullough, and F.A. Espinosa, Jr. 1994. *A coarse screening process for evaluation of the effects of land management activities on salmon spawning and rearing habitat in ESA consultations.* Tech. Report 94-4. Columbia River Inter-Tribal Fish Commission, Portland, Oregon. 127 pp. + appendices." (all available at www.critfc.org). I have also reviewed the Declaration of Dr. Boone Kauffman, the Declaration of Lindsay Davies, and the Second Declaration of Jamie McCormack filed in this case.

3. Livestock grazing has long been recognized as a major source of morphological alteration of stream channels and degradation of habitat quality for salmonids (Belsky et al. 1999). The impacts from livestock grazing can be itemized into their primary modes:

(1) Streambank damage. Streambanks collapse by mechanical breakdown from the weight of large animals grazing along the stream margin.
(2) Riparian vegetation removal and inhibition of regrowth. Riparian vegetation is removed by trampling or foraging. Removal of excessive amounts of grasses and shrub growth reduces the ability of vegetation to stabilize streambanks. Consumption or trampling of tree or shrub seedlings can maintain riparian vegetation in a perpetual early pioneer state. Grazing extent evaluations based on forage "stubble height" or the minimal targets contemplated in PFC ratings are not indicative of the needed restoration rates of streamside shrub and tree cover, shade, woody debris processes, and streambank vegetation rooting strength development that can stabilize overhanging streambanks.
(3) Loss of large woody debris (LWD). Over the long term, a sustained grazing program has the potential to impair the recovery of riparian tree cover. Instream LWD gets transported downstream or decomposes over time. At the same time, riparian trees that die may not be replaced if the intensity of grazing or trampling concentrated in the riparian zone is too great.
(4) Fine sediment delivery. Local streambank damage caused by grazing or trailing of livestock down collapsed banks into the stream channel creates significant input of fine sediments that can settle out in spawning beds or pools.

(5) Loss of overhanging banks. Streambank collapse eliminates the overhanging bank structure that frequently is established and maintained by riparian vegetation with high root strength and deep roots of shrubs, trees, deep-rooted grasses.
(6) Increase in water temperature. Reductions in riparian vegetation reduce shading of the wetted surface of the stream channel, causing water temperatures to increase.
(7) Channel widening. Stream channels frequently widen in alluvial floodplain zones where streambank damage is significant. When streambanks are broken down, the channel cross-sectional form becomes increasingly dish-shaped and bankfull width increases.
(8) Flow depth shallowing. As the streambanks adopt a shallow angle and allow channel widening, the depth of flow becomes increasingly shallow.
(9) Loss of pools. Increases in sediment delivery to stream channels from streambank damage, excessive ground disturbance in streamside zones, and general watershed disturbance (agriculture, grazing, road density and intensity of use) lead to sediment mobilization and transport to the stream system. Increased sediment delivered to stream channels leads to deposition in pools and obliteration of pools.
(10) Loss of fish cover structures. The loss of overhanging banks, loss of LWD, the shallowing of flow depths, filling of interstitial spaces among cobbles in riffles, and loss of pools by infilling with sediments eliminate essential elements of fish holding, summer feeding and rearing, summer escape habitat, and overwintering habitat.
(11) Spawning habitat degradation. Sediments contributed to spawning areas directly from adjacent streambank degradation or transport downstream to spawning areas from upstream streambank degradation zones infiltrate into spawning gravels. Higher levels of fine sediments in spawning gravels reduce the survival of salmonids rearing from the egg to alevin stages. Infiltration of fine sediments kills salmonids incubating in the gravel by a combination of entombment and reduction in intragravel water flow, thereby reducing the replenishment of dissolved oxygen at the surface of incubating eggs or alevins.
(12) Alteration of food base. Reduction of riparian vegetation from grazing that leads to riparian vegetation that is sparse by comparison with adjacent reference riparian zones will likely result in reduced input of terrestrial macroinvertebrates that serve as a significant portion of the food base for salmonids. Elevated water temperatures also lead to shifts in the aquatic macroinvertebrate community (reduction in Plecoptera, Trichoptera, Ephemeroptera) that can limit the productivity of drift-feeding salmonids (McCullough et al. 2015, 2016).
(13) Trampling of redds. In cases where livestock have direct access to stream channels and can walk on spawning areas, crushing of eggs in the gravel is likely to occur.
(14) Reduced dissolved oxygen in redds. In cases where livestock defecate directly into the stream, accumulation of organic matter can become significant enough that dissolved oxygen levels can decline in stream gravels where eggs incubate.

4. Redband trout in the Columbia Basin have two distinct life histories, anadromous (steelhead) and non-anadromous, with the non-anadromous divided into those that evolved with steelhead and those that did not. Life histories for non-anadromous forms are variable and

several have been described including adfluvial and fluvial migratory, non-migratory resident or stream-dwelling fish (Lee et al. 1997).

5. Redband trout are primarily spring spawners (March-June) although they may reproduce anytime of the year (Kunkel 1976). Redband trout spawn exclusively in flowing waters and typically migrate to spawning areas (Thurow 1990). Water temperature and streamflow likely affect migration timing. Following spawning, redband trout may remain in place until migrating to overwintering areas in the fall (Thurow 1990). Migratory juveniles typically move downstream to their ancestral lake or river after one to three years in natal areas.

6. Redband trout appear to have evolved over a broader range of environmental conditions than other salmonids and appear to have less specific habitat requirements (Lee et al. 1997). Redbands are often found in warmer waters than other salmonids. Populations in deserts along the southern margin of the Columbia basin inhabit turbid and alkaline waters that range from near freezing to over 25-degrees C (Kunkel 1976). In warmer and drier environments the loss of riparian cover has been associated with reduced numbers and production (Li et al. 1994). Thurow (1990) found redband trout most abundant in pool habitats and in association with cover components including undercut banks, large woody debris, and overhanging vegetation.

7. A study conducted by Zoellick and Cade (2006) represents an important source of information regarding redband abundance in sagebrush desert areas and the negative effects of livestock grazing on these populations. Zoelillick and Cade (2006) sampled redband populations in 30 streams in southwestern Idaho. They used a habitat model that measured site-specific habitat variables that included: stream shading, bank cover and stability, fine sediment in the substrate, cover for adults, and a landscape variable based on distance from the stream headwaters. Using BLM’s Habitat Suitability Rating (HSR) to determine habitat quality for

redband trout in sagebrush desert basin streams, they found as the HSR increased, the abundance of redband trout significantly increased. A model using just stream shade and distance from headwaters best predicted redband trout density and indicated that stream shade in the uppermost 50 m of a stream would result in the greatest increase in redband trout density.

8. According to the Second McCormack Declaration, livestock have access to 9.4 miles of perennial streams on the Hardie Summer allotment, of which 3.3 miles is on land managed by BLM. BLM appears to be aware that cattle have free access to these streams during the time that livestock are present, and are likely to do to these streams what free ranging livestock typically do (e.g., review by Belsky et al. 1999)—damage streambanks and impact riparian vegetation that significantly control water temperature increases. Streambank damage leading to channel widening and shallowing reduces effectiveness of any riparian vegetation to shade the stream and results in stream warming.

9. The survival time of fish exposed to water temperature takes the form expressed in the equation log (minutes survival) = a + b(exposure temperature, °C). Coefficients for *a* and *b* in this equation for fish acclimated at 20 and 24°C are listed in tables in Coutant (1972). Using this equation one can calculate 50% survival of a population acclimated to 20°C when exposed to 24, 25, and 26°C, etc., for example. All the salmonids listed in Coutant (1972) have *a* and *b* coefficients that produce very similar thermal response curves. Bull trout have a predicted ultimate upper incipient lethal temperature (UUILT) of 20.9ºC (Selong et al. 2001), but have a growth optimum of 13.2ºC. By contrast, redband trout have a UUILT of 26-27ºC (Sonski 1993, 1994, see McCullough 1999), but also have a growth optimum of about 13ºC (Gamperl et al. 2003). The other salmonid species (e.g., salmon and trout) have UUILT values ranging from 23 to 25ºC. Stream salmonids are all drift feeders and rely heavily on macroinvertebrate species that

also are very sensitive to increasing temperatures. Stream salmonids vary in their ability to occupy stream types by depth and substrate size and respond in varying ways to current velocity. However, with respect to water temperature, they all are among the most sensitive stream fishes to water temperature. They also all decline in local abundance as water temperatures increase from 12ºC to 28ºC during the summertime (assessed as a geographic distribution). Steelhead are anadromous forms of *O. mykiss*, and redband trout (an inland subspecies) are often more adapted to higher water temperatures. However, the slight metabolic advantage of redband trout over the related steelhead comprises at most about 1ºC in thermal resistance. For these reasons steelhead studies are reliable indicators of the likely direction of response of redband trout, and other salmonids very closely match this response too.

10. Livestock typically affect both the quantity and quality of fish habitat in a stream via their effects of grazing in riparian zones and trampling and breakdown of streambanks. In terms of habitat quantity, grazing along streambanks contributes to both an increase in sediment delivery to stream channels and a collapse of streams, which reduces the linear extent of overhanging streambanks. It also generally reduces the abundance of pools by leading to increased pool infilling by sediments. Also, an increase in cobble embeddedness from bed sedimentation reduces the interstitial hiding cover for juveniles needing to escape predators or conserve energy in current. An increase in width-depth ratio leads to a reduction in depth of flow, which can render riffles and glide habitats unusable for feeding and predator avoidance. Reduction in the quantity of these types of salmonid habitats reduces usable area and thereby causes a reduction in carrying capacity (Figures 1c, 1e). Carrying capacity is a measure of the potential of a stream to support a given abundance of fish of a given species.

11. Reduction in habitat quality is another means by which population abundance is limited. Reduced habitat quality causes a reduction in steelhead survival. Salmonid survival is a function of many key habitat variables. However, there are a few, such as water temperature, fine sediment, pool availability, LWD, and streamflow, that significantly govern steelhead survival from adult to egg to juvenile to smolt stages. Factors that increase summer water temperatures (e.g., increased W/D, decreased depth, reduced riparian canopy, reduced tree height, reduced riparian buffer width) impair the summer survival of juveniles and can cause the outright elimination of rearing of juveniles or holding of adults in major lengths of stream. Livestock are known to cause these types of impacts when allowed access to riparian corridors.

12. Factors that cause an increase in fine sediment delivery to stream channels (e.g., streambank trampling and collapse, reduction in vegetative ground cover by grazing and trampling, loss of rooting strength of riparian vegetation by progressive elimination of trees and shrubs and conversion to exotic grasses or bare earth, and overall watershed impacts of intense grazing) reduce the quality of many of the key redband trout habitats. Increased levels of fines infiltrate into spawning beds and increase embryo mortality (Figure 2 and 3); increase cobble embeddedness and reduce size of interstitial spaces; increase pool infilling, which reduces the effectiveness of pools as mechanisms for cover that can protect adults and juveniles against predators; contribute to channel widening and shallowing, which reduces the ability of fish to feed and grow effectively or to escape predators.

13. An increase in water temperature is a key habitat quality factor that is tightly linked to juvenile survival. Redband trout have an incipient lethal temperature that is approximately 26-27°C (Sonski 1983, Sonski 1984, see McCullough 1999). An optimum temperature for redband trout is 18°C or less (Madriñán 2008). Most salmonids, other than bull trout, are typically found

to decline in population density (numbers/100 m^2) toward zero where maximum water temperatures reach between 22 and 24°C (McCullough 1999). The carrying capacity of redband trout streams decreases above 18°C (Madriñán 2008, Figures 4). Redband trout from the Little Blitzen River and Bridge Creek (tributaries to the Donner und Blitzen River) have water temperature preferences of 13ºC (Gamperl et al. 2003) despite their upper incipient lethal temperature. That is, they grow better and perform better at relatively low temperatures. There are numerous sublethal effects that manifest themselves at much lower temperatures. Among these sublethal effects are increased prevalence of disease, inability to feed, swim, or avoid predators, impaired growth rates, inability to smolt, alteration of smolt timing, altered balance of competition with other species. Adults typically have lower thermal tolerance than juveniles.

14. For example, it has been found that there is a steady decline in juvenile salmonid abundance from mean or maximum temperatures of approximately 12°C to near zero at temperatures of approximately 25°C (Li et al. 1994 (Figure 5), Ebersole et al. (2001), Figure 6, Lessard and Hayes 2003, Figure 7, Madriñán (2008), Figure 4, Thompson et al. 2012, Figure 8). Declines in steelhead (*O. mykiss*) density (likewise including redband trout, *O.mykiss gairdnieri*, densities) occur at far lower temperatures than incipient lethal temperatures because of the numerous sublethal effects that cumulatively cause population impairment.

15. McHugh et al. (2004) modeled the daily survival of spring Chinook as a function of mean daily water temperature (Figure 1d). This relationship is to be applied as a multiplication of mean daily survivals for multiple consecutive days. It can be seen in a display of data using their Weibull equation that Chinook juvenile survival over a 6-consecutive day exposure to mean daily temperatures of X°C (i.e., denoting any given temperature tested), have lower survival than do fish exposed for 1 day at this temperature. Over the course of the summer (154 days), the

survival is highest at approximately 17°C but declines rapidly at temperatures higher than this (Figure 9). Activities such as livestock grazing in riparian zones that lead to increased water temperatures are likely to lower survival of salmonids. One can easily assume that survival vs. temperature relationships found for Chinook will be very similar in steelhead given the high level of correspondence in thermal sensitivities among these species (McCullough et al. 2001). Mortality in a salmonid population is a function of prior acclimation and cumulative time of exposure to stressful temperatures (McCullough 1999). Application of mathematical expressions of mortality due to acute thermal stress can be found in sources such as Coutant (1972). The McHugh et al. (2004) model describes mortality of a salmonid exposed to moderate to long thermal exposure histories. This model helps integrate what is observed in studies of numerous salmonids including Chinook, steelhead, redband trout, and bull trout that show observed field densities in relation to average or maximum water temperature (see example diagrams here).

16. Cumulative lethal plus sublethal effects of water temperature can be seen in salmonid distribution in streams. The probability of occurrence of salmonids is directly linked to maximum water temperature. For example, Dunham et al. (2003) showed that bull trout distribution is highest at water temperatures of approximately 10°C but the probability of occurrence declines steadily with increasing water temperatures (Figure 10).

17. Many of the modes of streambank and riparian damage that lead to alterations of the stream channel, bank structure, riffle and pool characteristics, W/D ratio, and solar radiation loading to the stream, lead to an increase in water temperature. In addition to water temperature, many of the other typical modes of livestock impact in riparian zones and along streambanks lead to elevated levels of fine sediment delivery.

18. There are reasons for concern about the fate of redband trout in the affected streams as well as other nearby grazed and ungrazed streams. These impacts due to climate change simply compound the problems created by grazing. Air temperatures have been increasing in the Malheur National Wildlife Refuge since 1950 USFWS 2012). Water temperatures in the Blitzen River are frequently near 25ºC in summer (Mayer et al. 2007, cited in USFWS 2012), which places redband trout under very stressful conditions. Water temperatures in Bridge Creek, which has very limited riparian vegetation, can reach 24ºC on hot summer days (Gamperl et al. 2003). Bridge Creek is supplied largely by snowmelt (Gamperl et al. 2003). In the region occupied by the Malheur NWR climate change will result in an increasing tendency for early snowmelt (USFWS 2012). Under climate change scenarios, early snowmelt is apt to be accompanied by summer drought. This will lead to reduced summer flows, which will only aggravate the summertime water temperature extremes. In addition, 14 streams were listed by ODEQ in their 2004-2006 303(d) list as water quality limited in the North Steens project area (BLM 2007). Geographically widespread water temperature exceedances indicate thermal impacts that can affect overall population viability. This places increased importance on protection and restoration of all habitat supporting redband populations until full habitat recovery is achieved. Many redband populations have already become extinct (Nehlsen et al. 1993, cited in Gamperl et al. 2003). While the Malheur Lakes redband trout SMU was judged by ODFW to pass minimal abundance targets (ODFW 2019), it was noted that these evaluations were made in high water years. This population is listed as potentially at risk.

19. If it is likely that resumption of grazing on the Hardie Summer allotment will lead to streambank and riparian damage, as Dr. Kauffman concludes, that is likely to cumulatively result

in loss of habitat quantity and quality and will reduce redband trout abundance and productivity and also lead to further spatial contraction of their range.

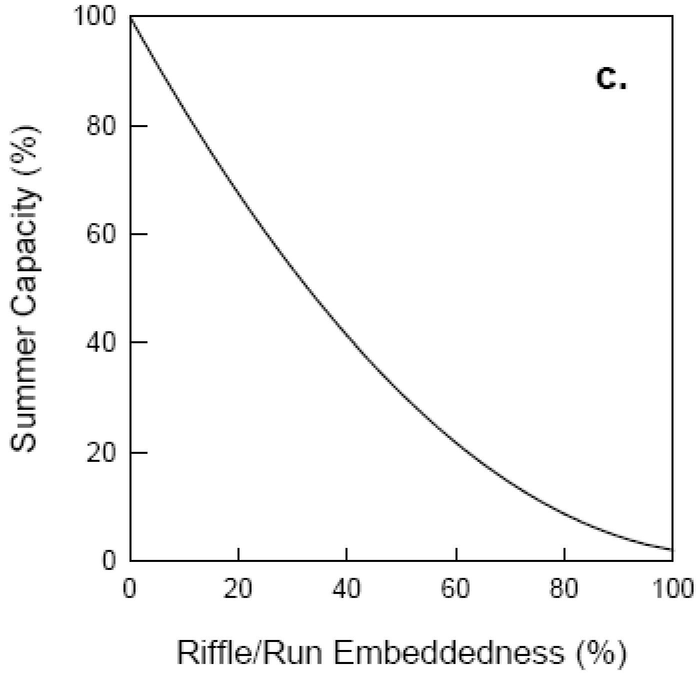
Pursuant to 28 U.S.C. § 1746, I declare under penalty of perjury that the foregoing is true and correct to the best of my knowledge.

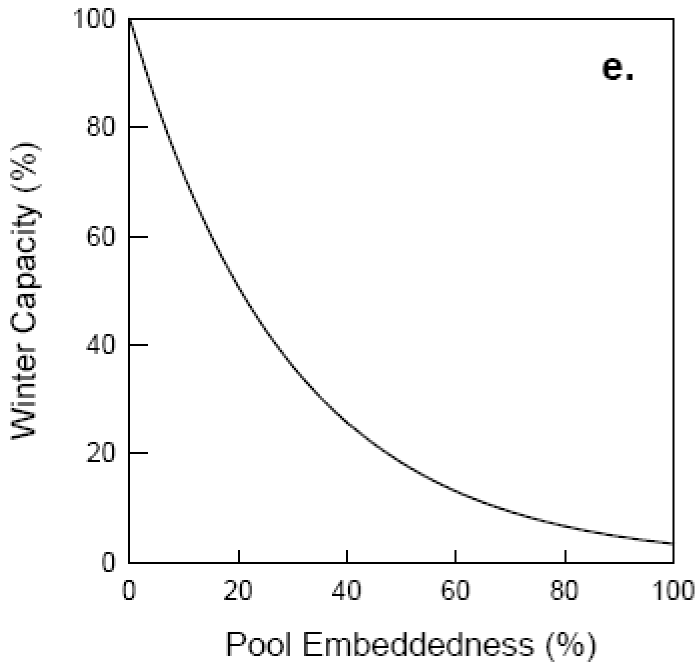
DATED this 23rd day of June 2019.

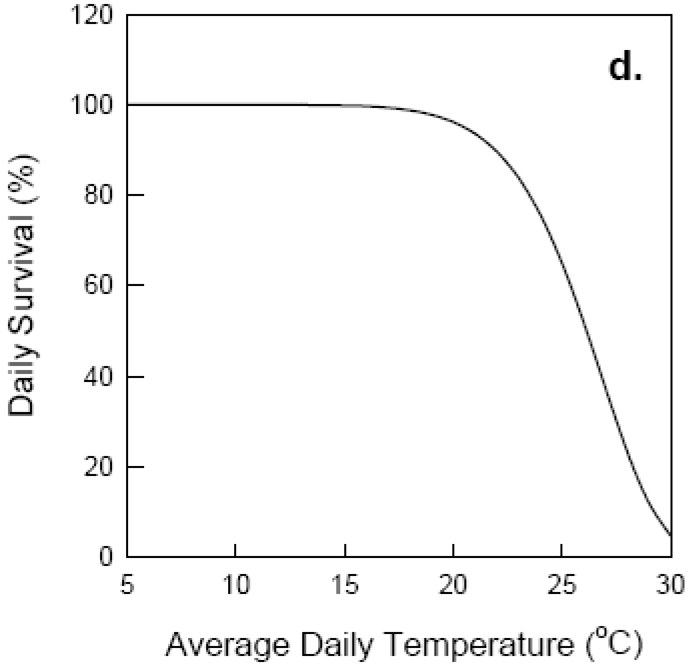
s/ Dale A. McCullough

Dale A. McCullough

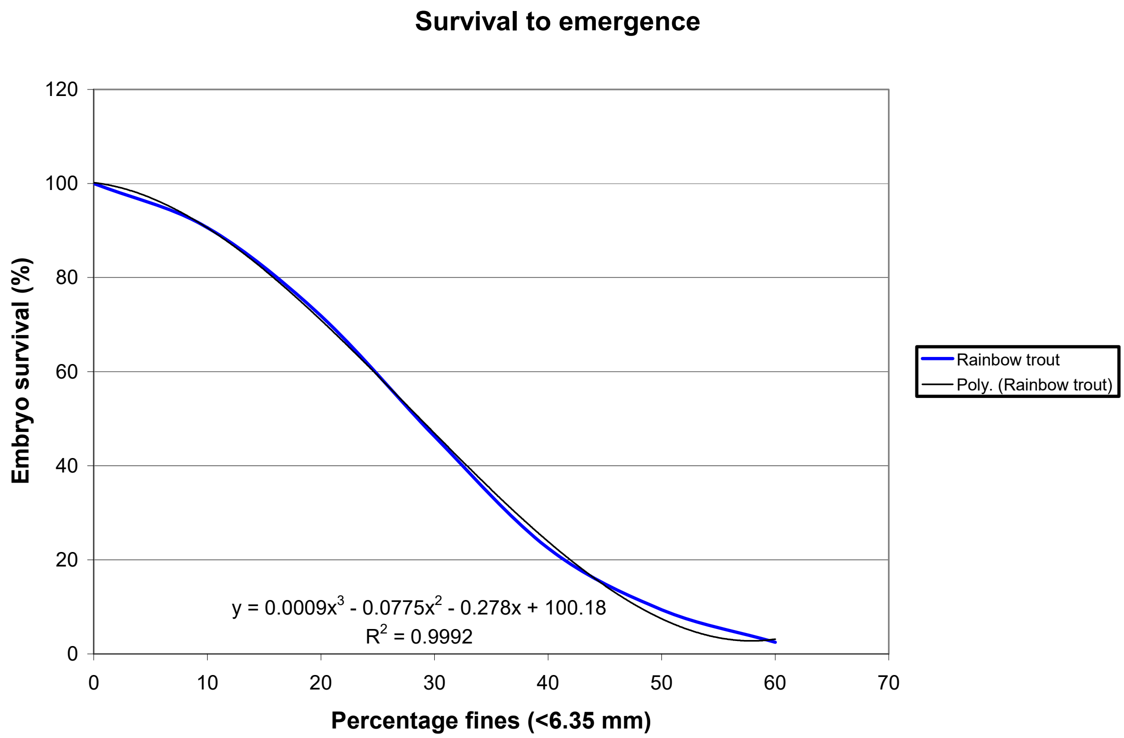
Figures

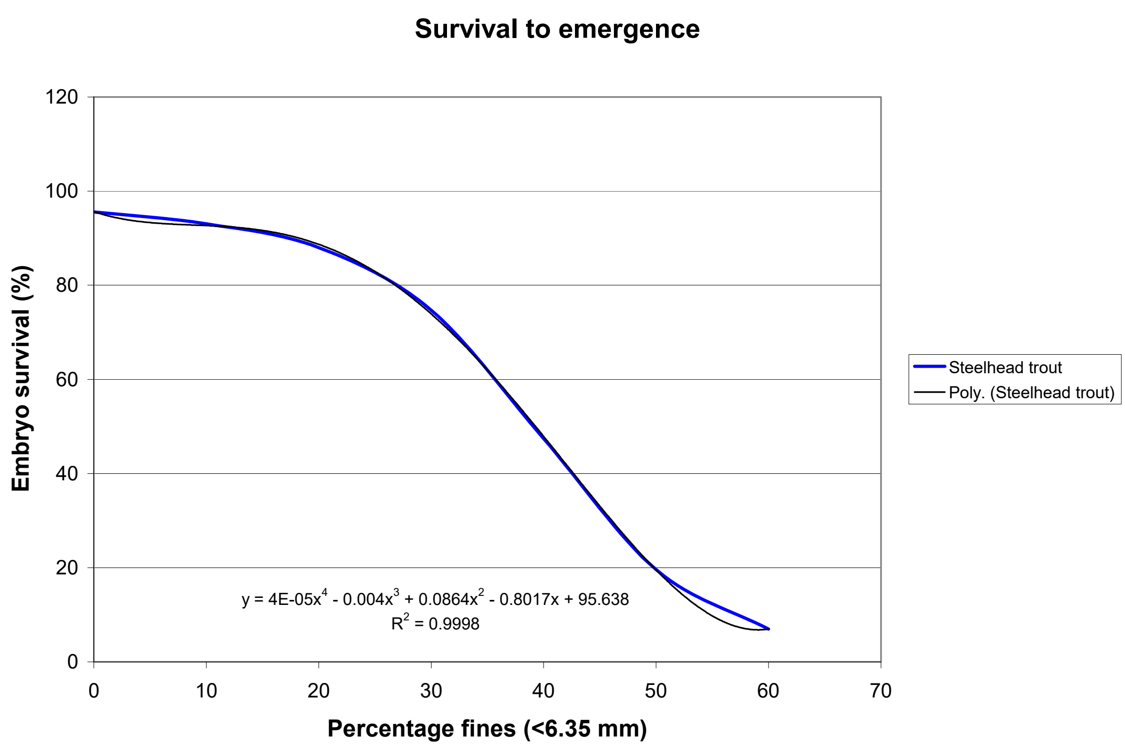

c.
Summer Capacity (%)
Riffle/Run Embeddedness (%)
0
20
40
60
80
100


e.
Winter Capacity (%)
Pool Embeddedness (%)
0
20
40
60
80
100



Figures 1c, 1e, 1d. From McHugh and Budy (2001). These relationships expressing daily survival as a function of average daily water temperature, winter capacity as a function of pool embeddedness, and summer habitat capacity as a function of riffle/run embeddedness, were the same relationships used by McHugh et al. (2003).





Figures 2 and 3. Charts derived from Bjornn and Reiser (1991) illustrating the effect of fine sediment in spawning gravel on embryo survival in rainbow trout and steelhead (*O. mykiss*).

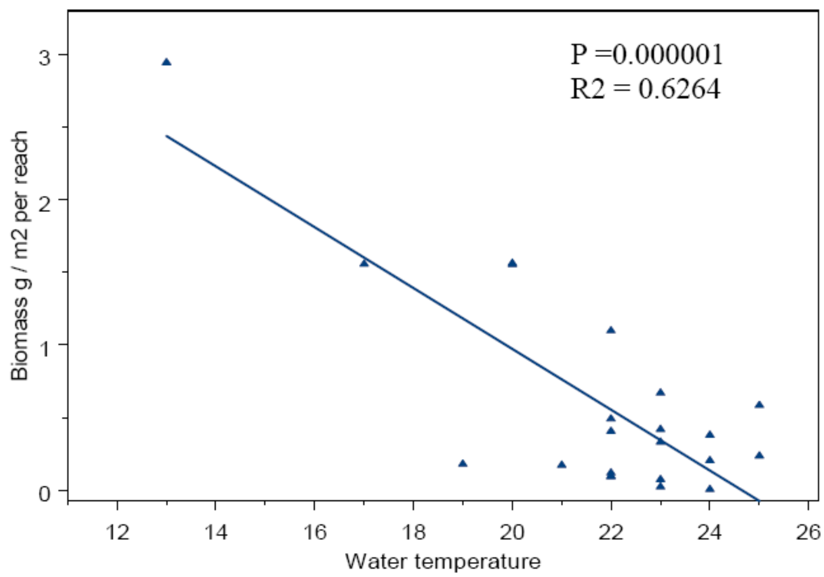


Figure 4.6 (B): Regression analysis between maximum temperature and trout biomass by stream reach

Figure 4. Relationship between water temperature and steelhead biomass (g/m^2) in Murderers Creek. Madriñán (2008).

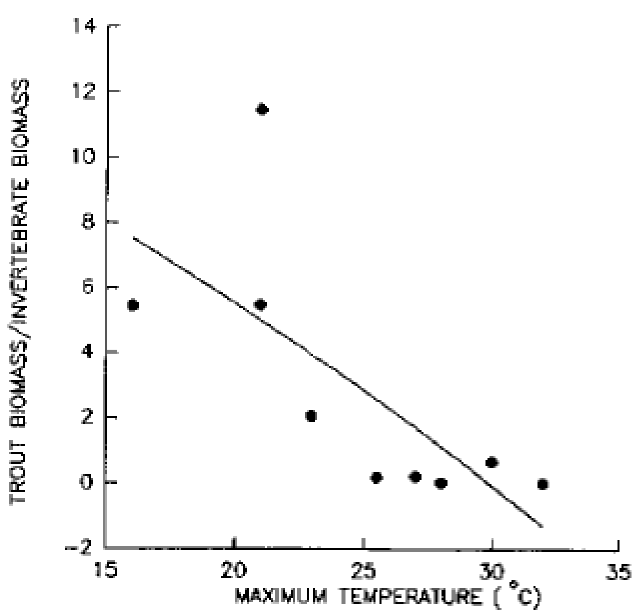


FIGURE 7.—Regression of trout biomass : invertebrate biomass ratio on maximum daily temperature for all reaches combined; $r = -0.71$, $P < 0.05$.

Figure 5. Figure from Li et al. (1994) expressing rainbow trout biomass in relation to invertebrate biomass as a function of water temperature.

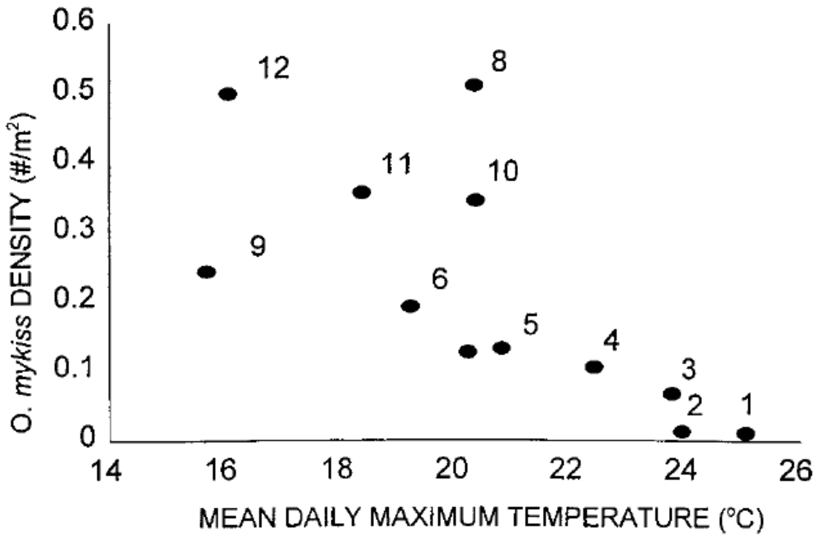


Fig. 3. Relationship between mean rainbow trout density and mean daily maximum water temperatures of 12 study reaches. The numbers refer to map codes for study reaches listed in Table 1.

Figure 6. Figure from Ebersole et al. (2001) expressing the relationship between rainbow trout density and mean daily maximum temperature from the Upper Grande Ronde, Wenaha – Lower Grande Ronde, Catherine Creek, and Lostine River subbasins, Oregon.

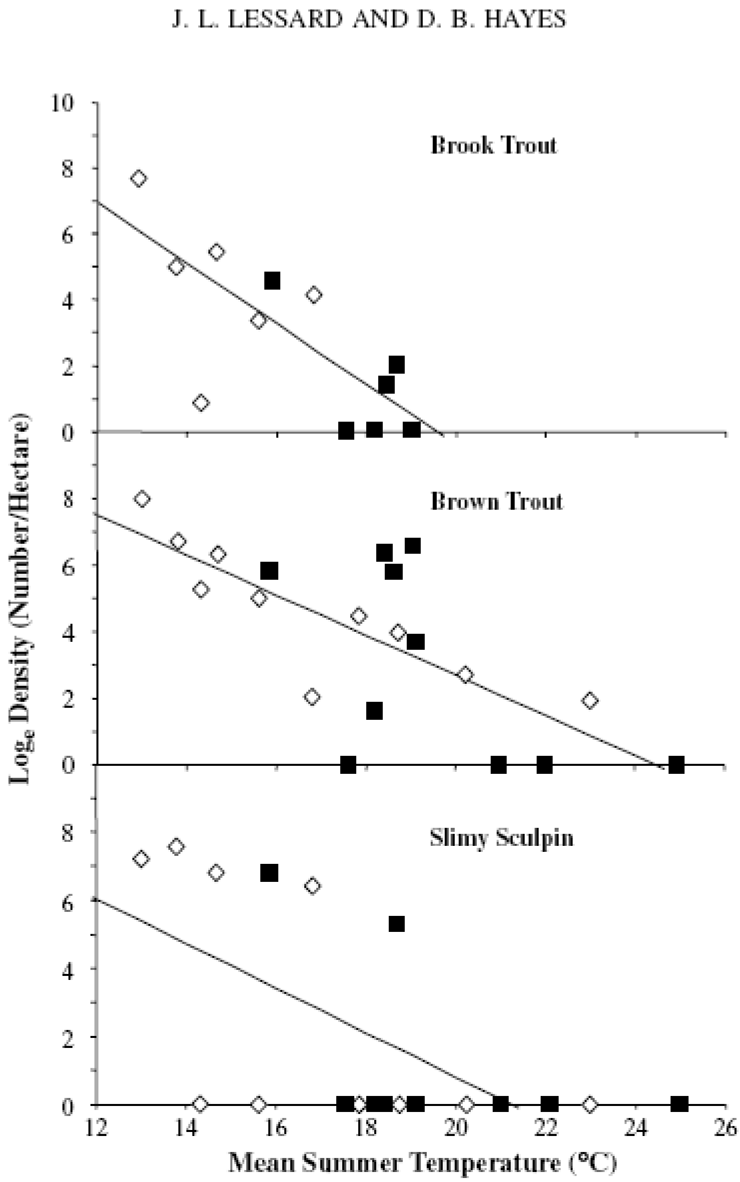


Figure 7. Relationship between log density fish (brook trout, brown trout, and slimy sculpin) and mean summer water temperature). Lessard and Hayes (2003).

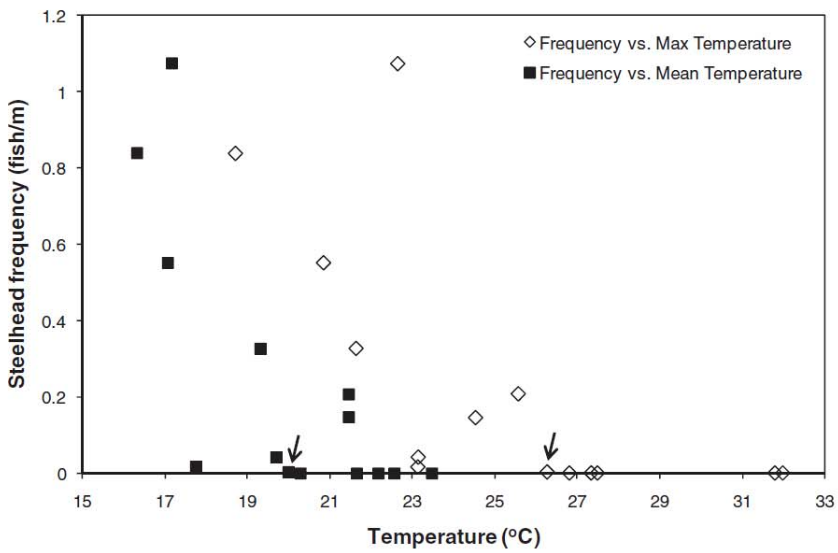


FIGURE 2. Steelhead density plotted against mean water temperature and maximum water temperature. The value producing D_{KBS} (the maximum difference between the observed and theoretical bivariate distribution) for each predictive variable is denoted by an arrow.

Figure 8. Figure from Thompson et al. (2012) expressing steelhead density vs. mean and maximum water temperature.

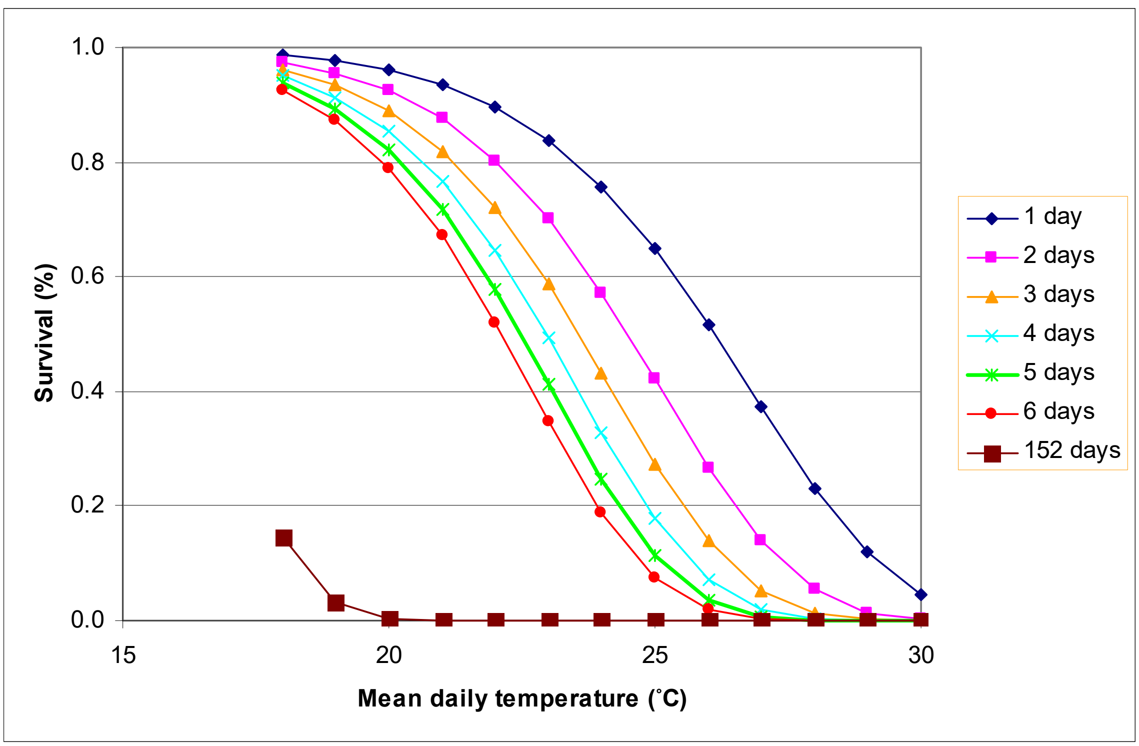


Figure 9. Expression of the Weibull function from McHugh et al. (2003) for mean daily temperature and Chinook survival. When there are 6 consecutive days at a mean daily temperature of X°C, the percentage juvenile survival is less than if this mean daily temperature

were assumed for only 2 consecutive days. Over the course of the entire summer, survival is greatest at approximately 17°C, but declines rapidly at mean daily temperatures above this value.

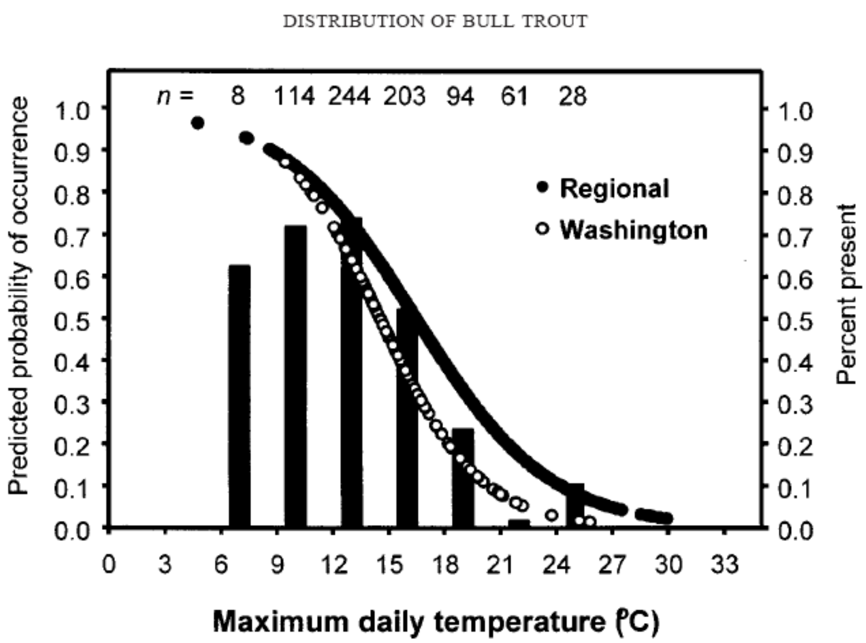


Figure 10. Occurrence of small bull trout in relation to temperature. The left y-axis shows the predicted probability of occurrence in relation to maximum daily temperature for the regional and Washington 2000 data sets (indicated by circles). The right y-axis shows the percentage of sites (both data sets; n 5 752 sites) where small bull trout were observed (indicated by bars). Bars are centered on 38C bins with sample sizes indicated above each. Dunham et al. (2003).

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